Biological Routes to Functional Ferroelectrics

Scientific Achievement

In this work, we demonstrate the integration of a phage-identified peptide with a pervoskite ferroelectric, lead zirconium titanate (PZT) and evaluate its potential to serve as a nanoscale biomolecular valve. A phage library containing seven random amino acids flanked by two cysteine residues, which are linked through a dithiol bond was used to identify peptide sequences that bind PZT. Selections yielded 5 unique heptapeptide sequences that show varying amounts of specificity and affinity for PZT surfaces. One sequence, TAR-1, was identified to bind PZT with both high affinity and specificity. Currently the molecular interactions between TAR-1 and PZT are being investigated using point mutations, FT-IR spectroscopy, and XPS.

The coupling of biology and inorganic materials in nano-electromechanical systems (NEMS) is also being investigated. A variety of photoresist materials have been deposited onto PZT films allowing nanochannels to be fabricated using electron beam lithography. We have experimentally shown that the exposed PZT at the bottom of these channels can be chemically addressed by bacteriophage expressing the PZT-binding peptide. Additionally, nanochannels have been fabricated that contain interdigitated Au electrodes that span the nanochannels, allowing the switching of the polarization state of the PZT.

Significance

Innovative approaches are needed for the design and fabrication of functional nanoscale materials and devices, particularly of components for fluid handling in NEMS, since their micron scale equivalents can not be simply scaled down. Biological molecules, which are optimally produced in nature, possess the requisite size and functionality to permit their use as the basis for such device components.

Currently, microfluidic structures are being constructed from polydimethylsiloxane as prototypes to test the stability of the PZT-bacteriophage composite under flow conditions and study the fundamentals of tethering biological molecules to the PZT surface within the confined space of a nanochannel. These devices are being prepared with increasingly smaller dimensions with the intent of ultimately preparing devices with channels that are approximately 100 nm wide.

Performers

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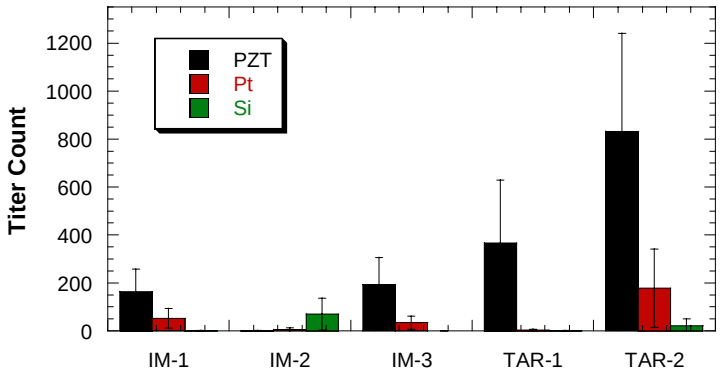
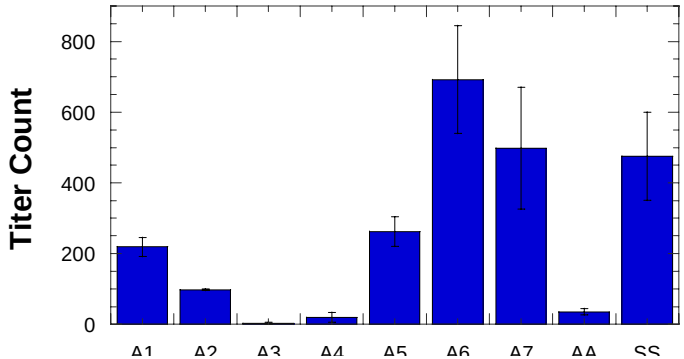
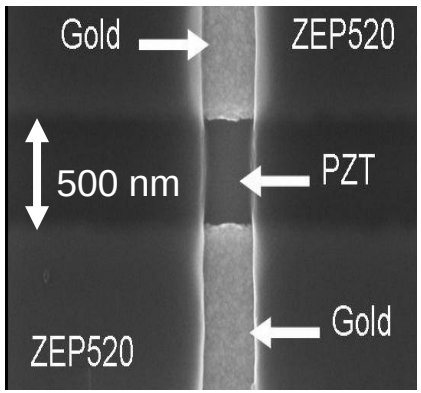
- ***Phage display has been used to identify peptide ligands that selectively bind a perovskite ferroelectric, lead zirconium titanate (PZT)***

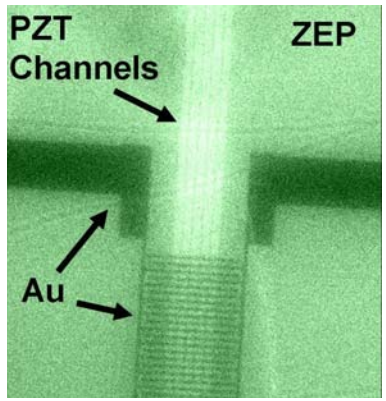




- **TAR-1 peptide selectively binds PZT**

- **Alanine scan is the first step in determining binding mechanism of TAR-1 to PZT**





- **Phage selectively bind to PZT nanochannels patterned in ZEP photoresist, allowing the testing of device fundamentals**

- ***Peptide ligands will permit the coupling of soft and hard materials and will enable the advancement of nanoscale functional materials and devices***

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